SOME OBSERVATIONS ON SOUNDING, AND THE ADMIRALTY CHARTS.

By Lieutenant H. W. H. HELBY, R.N.

Thursday, 23rd March, 1905.

Rear-Admiral Sir W. J. L. WHARTON, K.C.B., F.R.S. (late Hydrographer of the Navy), in the Chair.

[In the absence of the Lecturer, the paper was read by Lieutenant H. T. A. BOSANQUET, R.N. (Retired).]

THE Admiralty charts are familiar to all British seamen, and great reliance is placed on them; so much so, that merchant-ships, especially steamers, having an Admiralty chart of the coast on board, rarely trouble to use the lead so long as they are able to fix their position by the land.

It is taken for granted with a simple faith that if the chart shows five, ten, or twenty fathoms, or any other depth at any particular spot, nothing less than that depth of water exists there; and when occasionally a vessel does strike the bottom where the chart shows that she should have been able to float, or even if the chart shows no sounding at all, those who lose their money by the accident are considered to have a legitimate grievance.

And yet the Admiralty charts lay no claim to infallibility. No less a person than the late Hydrographer has laid down that it is impossible that any survey can be so minutely done as to make absolutely certain that no pinnacle rocks remain undetected, and that this opinion is correct is proved by the frequency with which new rocks turn up in recently surveyed areas.

Moreover, many of the charts in existence are from surveys of forty or fifty or even more years ago, and in those days it was only in the most frequented harbours that the sea bottom was really carefully and systematically examined.

The pamphlet issued by the Hydrographic Office, entitled, "Notes Bearing on the Navigation of H.M. Ships," directs particular attention to the date of a chart as a guide to its trustworthiness; but it is doubtful if this is appreciated to its full extent even in the Royal Navy, still less so in the merchant service.

A steamer, anxious to save time and coal, seeing fifteen fathoms marked on the chart a few cables off a point she wishes to round, will cut round the point at that distance or even closer, confident that it is steep-to, not realising that possibly that fifteen fathoms is the

only sounding that was taken off the point, and that an unmarked rocky ledge may run out on one side or other of the sounding to a greater distance from the shore.

In the days when these charts were made, seamen were constantly exhorted to rely only on the lead. "The lead is the only sure guide" was the common phrase, and one comes across it sometimes even in the present editions of the sailing directions; but what steamer ever slows down nowadays to use the lead on a charted coast?

The belief in the lead is, in fact, on the wane, and, indeed, if the chart gives the general depth of water, the lead can do no more; it will not give notice of approach to pinnacle rocks, which are the greatest dangers to navigation at the present day.

Let me give two examples. In the year 1890 the British India steamer "Quetta," in charge of an experienced pilot, struck on an uncharted rock in the Adolphus Channel, a little to the southward of Torres Straits. She was pursuing the course that had been followed by ships of that line for several years. The general depth of water shown by the chart, which was apparently fairly well sounded, was eleven fathoms. When the channel was re-surveyed shortly afterwards, the diameter of the base of the rock, which had nine feet on it at low water spring tides, was found to be only about two hundred yards. That is to say, eleven fathoms would be obtained on each side of the rock at a distance of one hundred yards from its centre. Had the "Quetta" been going only five knots, and heaving the lead from both chains, she could not have stopped, after the leadsman had got shoal water, in time to avoid striking. As it was, the ship sank in a few minutes, and there was distressing loss of life.

The Duke of Buckingham shoal, on the same coast, is another of the same character, a coral head. The place was surveyed in 1892 on a scale of two inches to the mile, and the lines of sounding run by the surveying vessel were parallel to each other and about two hundred and fifty yards apart.

A rock had previously been reported to exist somewhere in the vicinity, but although a special search was made, it was not discovered. A few years afterwards the "Duke of Buckingham," a deep draught ship, confidently using the newly-published chart, struck on the shoal. Fortunately, in this instance, there was no loss of life.

Coral waters are, no doubt, especially dangerous, but a careful examination of almost any place where the soundings are irregular (as, for example, the west coast of Scotland) will show how very little warning the lead will give of a vessel's approach to one of the rocky pinnacles that abound in such places.

The conditions of navigation are thus quite different to what they were in the days when charts were few and every seaman felt his way for himself with the lead.

Every year the opinion will become more fixed that an Admiralty chart ought to be as reliable as a "Bradshaw's Guide."

Is this opinion to be combated, and are seamen to be convinced that they must still trust to their own precautions for avoiding unknown dangers, or are the charts to be so improved that we can feel confident that there are no unknown dangers to be guarded against?

I believe the first to be impossible, and I am certain that the second in its full extent is no less so. The solution seems to lie in a combination of the two.

Let us take a rapid glance at the evolution of modern hydrography. Some time in the 16th century printed maps of the sea began to make their appearance. But they showed nothing more than a rough, and largely imaginary, outline of the land. The sea was covered all over with pictures of ships, dolphins, savages, and other strange hieroglyphics. What was aimed at was to show the correct bearings and distances from port to port, and for this purpose lines of direction were frequently ruled across the sea. These maps were innocent of soundings. In pilotage waters local knowledge was relied on.

Captain Cook, though not the originator, was the first great exponent of accurate surveying. But his work was rapid, not detailed. His first care was accuracy of geographical position. Such reefs and shoals as came under his notice as he coasted along he placed on his chart, but he could not afford the time to work out channels or harbours.

The exploring tadpole was, in fact, only just beginning to turn into the surveying frog. The change went on gradually under Captains Vancouver, Flinders, Owen, King, Stokes, and others, but the next great innovator was Captain, afterwards Admiral Sir Francis Beaufort.

When he became Hydrographer in 1820 he threw a tremendous enthusiasm into the surveying business, and expected it from everyone under him. Overpowering zeal for the great work on which he was employed was to be the rule for every surveyor. Ordinary naval duties were pushed to the background, and the surveying service became the special and separate branch it has ever since remained.

It was probably about this time that pride of accurate triangulation succeeded, or, rather, was superimposed upon, pride of geographical accuracy. Coast-lines were very much more carefully charted. The compass as a surveying instrument dropped more and more out of use in favour of the theodolite. A stranger using the chart could now fix his position with certainty by cross bearings. No reef that showed its head above water at the lowest spring tides was ever left out, the sea was carefully scanned from commanding points on stormy days that any breaking shoal might be discovered. Information was sought from local fishermen and others of submerged reefs, and so well was this work done that the sea in surveyed waters was practically safe for the shallow draught vessels of that date. The Admiralty charts thus acquired the reputation for reliability which has been their proud possession to the present day.

If, however, anyone acquainted with marine surveying examines the original charts of 1840 or thereabouts, he will be struck by the scarcity of soundings. Except in selected harbours, which were sometimes done on a large scale, systematic examination of the sea bottom was not undertaken. Systematic soundings in parallel lines on and off shore is a lengthy business even nowadays, when we have the advantage of steam for ship and boats. In those days it was almost an impossibility. At any rate, the time required for it, and consequently the expense, was so great that it would have been absurd to undertake it on coasts as yet unfrequented, and which might possibly not be frequented by vessels for decades to come.

Enough soundings were obtained when tacking off and on, or pulling along the coast in boats, or going to and from the various coastal stations to show the general character of the bottom, and this

was all that could be expected. The charts were generally published on a small scale, and to the inexperienced would appear, from the apparent closeness of the figures, to be thoroughly sounded. But this was seldom the case.

The advent of steam-ships, which are not precluded by considerations of wind from hugging the coast, and the increase in the draught of all vessels, were the new elements that rendered more detailed sounding necessary.

The method generally adopted was to run lines of soundings parallel to each other and perpendicular to the coast, and at distances apart varying according to the scale of the chart.

Speaking generally, lines a quarter of an inch apart on the paper were considered to be fairly close for water under twenty fathoms. Over that depth the lines were wider. So that on a scale of one inch to the mile, a common scale a score of years ago, and fairly often used still, a rock a quarter of a mile in diameter at the base might remain undetected if it happened to be midway between the lines of sounding. In a recent "Notice to Mariners," referring to the rock in Yung Ching Bay, on which H.M.S. "Leviathan" grounded, the following caution is issued:—"As the survey of this part of the coast is on a scale of only one inch to the mile, it is necessary to be cautious in taking up anchorages, as it is quite possible other pinnacles may exist, and it is advisable to sound round the vessel when anchored." When the rock was subsequently examined it was found to have $2\frac{3}{4}$ fathoms on it, and soundings of under five fathoms extended to a distance of one and a half cables from the summit.

The greater part of the passage inside the Barrier Reef on the coast of Queensland has been surveyed on a scale of two inches to the mile. The general depth in the middle of the channel may be taken as from twelve to twenty-five fathoms. The lines would be about 250 yards apart. As was shown in the case of the Duke of Buckingham shoal, it is quite possible for a pinnacle to remain undetected between them. The lines can, of course, be closer than this, but four or five lines to the inch is the average for most surveys, economy of time being an important consideration.

The coasts of England and Scotland are being surveyed on a scale of 6·9 inches to the sea mile, this scale being adopted because it is the scale of the maps published by the Ordnance Survey, from which the coast-line and topography are to some extent derived. Four lines to the inch represents in this case a distance apart of 74 yards. Recent surveys conclusively prove that even this distance is too great on an irregular bottom.

The different kinds of bottom fall naturally into three great divisions, which may be named as follows:—

1. The Tidal Deposit bottom, which occurs in places where sand or mud has been deposited on the floor of the sea for long ages.
2. The Aerial Denudation bottom, the contours of which were formed above water by aerial denudation, and which has sunk below the sea too recently to allow of a thick covering of deposit.
3. The Coral bottom, formed by the deposit of broken pieces of dead coral, coral sand and mud.

As is always the case in nature, these divisions overlap one another, but each has some characteristic features.

The Thames Estuary, the Downs, and Yarmouth Roads are instances of the first. In this kind of bottom the detached shoals are always found to lie more or less in line with the direction of the tidal stream. The direction of the stream influences the whole contour of the bottom, and lines of soundings run across the stream will strike the steep slopes perpendicularly. This is considered to be the most accurate method of sounding. In the three cases given the adjacent land is all of a flat and smooth description. This is very frequently the case near tidal deposit bottoms, or perhaps it would be more proper to say that the latter generally results from the former. There are no steep submarine cliffs or craggy summits to be covered over and smoothed down. The mantle of mud and sand overlays everything, much in the same way that a mantle of snow covers a flat country on dry ground. But if the geological character is such that there are craggy ledges or pinnacles, it is obvious that the greater the deposit the more gentle will be the slope approaching them, and therefore the greater the ease with which they will be detected by the lead.

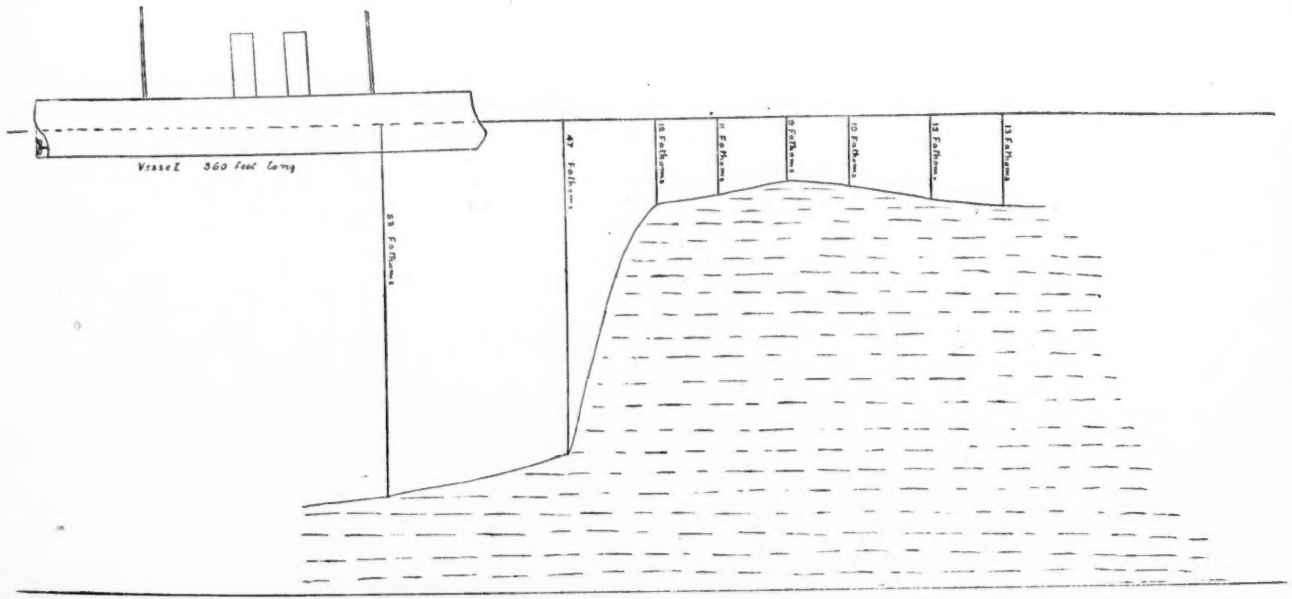
The second type of bottom, which I have called that of aerial denudation, is well exemplified in the Scottish sea lochs. Sir Archibald Geike, in his book on the "Scenery of Scotland," shows that the Scottish coast-line has been, in comparatively recent geological times, many hundreds of feet higher than it is now. The bottom of the lochs was shaped in the open air by the agencies of rain, frost, and mountain torrents, and was, no doubt, irregular, craggy, and precipitous, as the land surface is now. Either from want of time, or because comparatively little sediment is carried down from the hard land surface, the bottom is only thinly coated with deposit, very frequently it is quite bare rock or only covered with seaweed. The submerged ledges and pinnacles are consequently quite steep-to, and the most careful sounding is required to get any indication of them. The general irregularity of the bottom complicates matters still further, for among so many various soundings it is difficult to decide which are indications of dangerous rocks and which are not. The only way out of the difficulty is to sound as closely as ever time will admit of.

If a well executed chart of one of these lochs is compared with a geological map of the district, it will be noticed that the direction of the lines of rocky ledges corresponds to the direction of the strike. If we look at the land itself we see that this might have been expected. Everywhere we find ridges, on one side of which are little cliffs formed by the breaking off of the upturned strata, while the other side slopes away more or less gradually, according to the dip. This kind of bottom should therefore be sounded at right angles to the strike.

The third division is the coral bottom. We may take the great Barrier Reef as a good example.

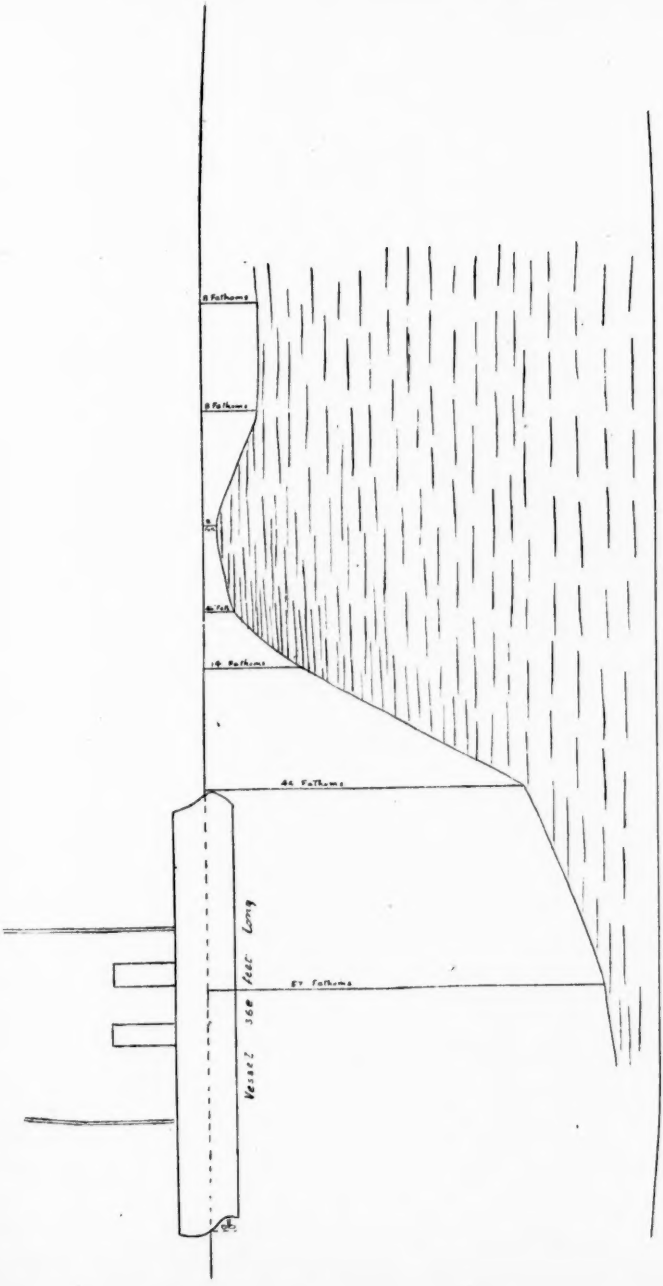
The outer reef faces the open ocean, and the coral animals, revelling in the wash of the breakers, grow continually outwards. In their rear they leave a submerged plateau covered with their bones and with a soft white mud formed by the calcareous matter of which they are composed.

On this plateau grow numerous minor reefs, which are the principal danger to the navigation of these parts. I believe that very

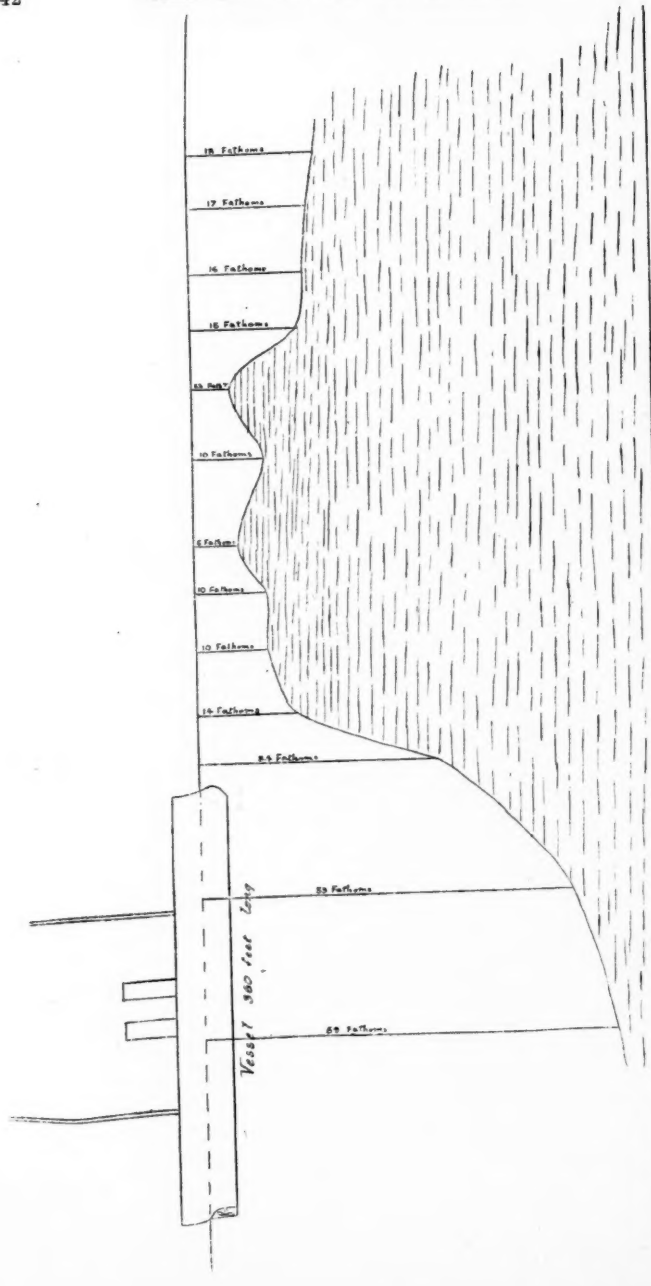


SECTION SHOWING SUBMERGED SLOPE. LOCH NEVIS, SCOTLAND.

Scale : 10 fathoms = $\frac{7}{16}$ inch.



SECTION SHOWING SUBMERGED SLOPE. LOCH NEVIS, SCOTLAND.
Scale : 10 fathoms = $\frac{7}{10}$ inch.



SECTION SHOWING SUBMERGED SLOPE. LOCH NEVIS, SCOTLAND.

Scale: 10 fathoms = $\frac{7}{16}$ inch.

little is known about the growth of these minor reefs, some of which come up to the surface and some of which only rise a few feet from the bottom. Divers who have been down on them report them to be so foul that it is only with great difficulty that they can keep their pipes clear, and when sounding over them the lead-line frequently becomes entangled.

They appear to be characterised by a profusion of branching madrepores, with great lumps of hard brain coral interspersed. These latter lie about like big boulders, and may be easily missed by the lead, however careful the sounding, while from their unyielding nature they are especially dangerous to ships. Whether these minor reefs indicate slight rises of the original bottom, inducing the coral animals to grow there, or whether they are formed promiscuously, does not seem to have been settled, nor is anything yet known for certain about the rate of their growth.

The opaqueness of the water, caused by the suspension in it of minute particles of lime, renders it almost impossible to see them even when they rise to within a couple of fathoms of the surface. There would seem to be no rule to show in what direction they may be expected to lie. Some are elongated, some roughly circular. In fact, they are of all shapes and sizes, and the old rule of sounding perpendicularly to the coast seems to be the best one to go by.

Enough has been said to show that without infinitely close sounding it is impossible to be sure of having located every danger to navigation. There must, of course, be a limit to the closeness of the soundings. Time does not allow of the whole sea in pilotage waters being covered with soundings twenty yards apart, and even if it did some pinnacles might still be missed. This being the case, it becomes a question whether any means can be found to remove the risk that deep-draught vessels run of striking on unknown pinnacles in places that are supposed to have been surveyed.

I submit that the only way to make quite certain that any area is clear of dangers is to sweep it.

Now sweeping is an operation that most surveyors dislike. It takes an exceedingly long time, and gives, of course, if the channel be clear, only a negative result, which does nothing to increase the apparent output of work. One would only occasionally be rewarded by a find in the shape of a pinnacle that had escaped the sounding boats. There is no special apparatus for sweeping, and very few people have had any practice in it, all of which tends to keep up the disfavour with which it is regarded. I venture, however, to suggest that if modern mechanical appliances were drawn upon, an arrangement could soon be found which would render sweeping both easy and rapid.

There is an excellent machine which goes part of the way towards solving the difficulty, and which has already been in use for some years, known as James' Submarine Sentry. It consists of a wooden kite which is towed astern of the vessel, at a depth below the surface that is governed by the amount of towing-line paid out. The kite carries a trigger projecting from its under side which, on touching the bottom, disengages a slip, allows the kite to rise to the surface, and rings a bell on board the vessel. Properly used this machine ensures that the sounding vessel does not actually pass over any considerable inequality of the bottom without detecting it. Its action

is, however, limited to the single line along which it travels, and it is possible for it to pass within a few yards on one side of a pinnacle and give no warning. But it is probable that with a few experiments the submarine sentry could be developed in such a manner that it would sweep a track perhaps a hundred yards wide.

The following is a suggestion of the direction that the development might take. I recognise that what seems to be simple on paper often presents unexpected difficulties when put to the test, but this is a condition common to every new device, and if once rapid sweeping is allowed to be desirable and important, I think these little difficulties will quickly be surmounted.

I suggest that instead of one kite traversing a single line astern of the ship, two kites be used, one on each quarter, and that each kite should be fitted with a fixed rudder which will cause it to sheer out on the quarter from which it is towed. Also that the two kites be joined together with a wire line (the wire used in Lucas' Sounding Machine would be suitable). The joining-line should carry at intervals of about thirty feet bunches of fish-hooks, or very small grapnels with sharp points that would catch against any hard substance or stick into any seaweed with which they came in contact. One end of the joining wire might be attached to a spring slip on one of the kites, so that any extra strain would cause it to slip, and the kites would immediately diverge more widely in obedience to their rudders, or it might perhaps be attached to the triggers of the kites and so cause them to disengage and come to the surface when the grapnels found a rock, or the grapnels might be fitted into small cartridges of phosphide of calcium which would be torn open and which would float to the surface and give notice by their smoke.

The drag of the water on the joining-line and the strain of the diverging kites would keep it in a horizontal position and prevent the centre from sagging down. The ship could probably travel at a speed of seven or eight knots, so that a good deal of ground could be swept in a comparatively short time.

The places first selected for sweeping would naturally be entrances to harbours when the bottom is rocky and uneven, rocky channels through which ships are obliged to go, and off rocky points round which ships are continually passing. The area thus swept might be shown on the chart by a light blue tint with large, faint blue figures on it showing the depth to which it had been swept.

As these blue patches gradually accumulated on the charts and seamen got accustomed to them, they would come to prefer to use the swept tracks to those that were not so guaranteed, and it is likely that the underwriters would make their use a condition of insurance. Accidents would become of less frequent occurrence, and surveyors would be saved the mortification of seeing ships come to grief through a misplaced confidence in their newly-completed charts.

The Otter Sweep.

An Arrangement for Sweeping for Rocks with one vessel only.

The sweep is on the principle of the trawl known as the otter trawl, which has been in use among the North Sea fishermen since 1894.

In the otter trawl, two flat boards called otters are attached, one at each end of the headline of the net, in such a way that when the trawling vessel moves ahead the two boards sheer outwards and stretch the net from 60 to 120 feet, according to the speed of the vessel.

In the otter sweep the otters are connected only by a thin wire, which offers small resistance to the water. They will therefore sheer outwards to a much greater extent than when a heavy net has to be dragged along the bottom. The sweep differs from the trawl also in this respect: that while the latter is dragged over the bottom, the former has to be towed at a definite depth below the surface.

This is effected by attaching the otters to buoys by a known length of wire, the buoys being of such a shape as to offer the least resistance to being towed, in order that the suspending wire may be as nearly as possible perpendicular.

A correction must be applied to the length of the wire to arrive at the depth of the otters below the surface.

The otters are circular iron discs, weighing about 25 lbs., and they are fitted with a sloping flange on each side, which slopes outwards and downwards, and also forwards and downwards, the object being that the flanges should act as horizontal rudders, causing the otters to keep at the greatest depth permitted by the suspending wires. Without this the speed at which they are towed might cause them to rise, in spite of their weight.

The joining wire between the otters is thus stretched as taut as possible, and should it meet with any obstruction it must carry away, allowing the otters freedom to diverge and sheer right out on each quarter, by which means notice is given that a pinnacle has been met with.

Captain A. M. Field, R.N. (Hydrographer to the Navy):—Although it is true, Sir, as the lecturer has stated, that it is impossible that any coast survey can be so minutely done as to make absolutely certain that no pinnacle rocks remained undetected, yet lines of soundings on the 6·9-inch scale can certainly be run so closely as to reduce the risks to very small proportions. It is a question of time—which is money—to make sure that there are no dangers existing. Given a sufficiently large scale, with lines of soundings closely spaced, it is highly probable that some indication of any danger that exists will be disclosed. This probability could be still further largely increased by crossing the lines of soundings, and if necessary recrossing them at a different angle; but I do not pretend to say that even that provides absolute security; still, there is a very high degree of probability of security. As a matter of fact, however, it is not on the large scale surveys, which are closely sounded, that undetected dangers are of frequent occurrence; it is on the small-scale surveys of the coasts of an inch to the mile, or less, and that is the great difficulty to be overcome. Success in finding hidden dangers mainly depends—in fact I might say entirely depends—upon the scale of the survey. When you determine the scale of the survey you practically say to what limits the soundings are to be run. Methods in ordinary use, therefore, are efficient, though laborious, I admit. The scale of coast surveys is governed to a large extent by the distance to which it is necessary to carry the soundings from the points which are used for fixing. The station pointers that are used in the boats must be of moderate size; therefore, of course, you cannot increase the scale of a coast survey

beyond certain limits, and as a matter of fact the inch scale will still, I think, have to be retained. But if you want to examine the ground still more closely than can be done by merely running the lines parallel to one another, then you must cross the lines of soundings and recross them at another angle. If the lines are closely spaced, that should give at any rate a very high degree of probability of discovering any dangers. There is no doubt, however, that a system of sweeping would change the various degrees of probability, which depend on the scale, into certainty if that system was really efficient; but unfortunately it has yet to be invented. However efficient a system of sweeping might be, it would still be necessary to develop the general conformation of the bottom by the ordinary methods of sounding, and for that purpose the original parallel lines of soundings would still have to be nearly as closely spaced as at present. It then becomes a question, whether it may appear desirable to sweep or to run intermediate lines, with re-examination of any doubtful spots. The latter plan is that which is usually adopted now; but if a method of sweeping which embraced a sufficient breadth of front could be devised, then the system would be very desirable. You must have a sufficient breadth of front to provide for the lines over-lapping one another. On small scales this is especially necessary, or the lines would be so close together that your fixes would fall on top of one another, and in the absence of ideal transit marks, which occasionally you do get, but very seldom, you would be dependent upon the fixes while sweeping; but if the lines did not overlap one another so as to cover the whole ground effectively, you would be worse off than before, because soundings (even though they may be on the line) give you position indications, whilst sweeping gives you only negative information. It is on small-scale surveys that sweeping would be most useful if it were practicable, as it is on those scales that undetected rocks are most likely to occur; but in order to sweep large areas on small scales, a wide front is absolutely essential, and that is the difficulty which has to be overcome before sweeping can be practised to any advantage. Sweeping on large scales and over small areas is easier and is sometimes carried out, but only in the last resort. After you have closely sounded over a suspected area and can find nothing, then it is sometimes advisable to make certain of it by sweeping; but it is a long operation, and the chances are if you choose to sound on a very large scale or on transit covering the ground minutely, you will clear the matter up satisfactorily quicker than you could by sweeping. Large scales make it easier to sweep, because you are able to fix the lines so accurately that you can afford to sweep on a small front. In practice, however, the sounding method is generally the quickest and equally efficient, and it is only on rare occasions that it is necessary to resort to anything else. I should welcome any efficient system of sweeping which would give the broad front which I have emphasised, but I am afraid the system of kites proposed by the lecturer is not a very practical solution of the difficulty. I have not studied the otter trawls, and I should be sorry to offer an opinion upon them before doing so; it may be a feasible solution, but I should not like to say off-hand. If anybody can invent something of that sort which is really practical, I shall be very glad to see sweeping carried out; but until then I think the ordinary method of sounding is sufficient.

Rear-Admiral USBORNE MOORE :—The Hydrographer has gone so fully into the question that there is very little for anyone else to say; but I would submit that if you look at the Board of Trade returns you will

find that very few vessels at all are lost through inexact charts. At one time I thought there were a great many; but I once borrowed ten years' Returns from the Board of Trade, and on going through them very carefully I found that, at the outside, about one per cent. of vessels were lost from what might be called errors in the charts. A great deal is said about errors in charts causing the loss of ships, but there is very little reality in this complaint. The remedy which appears to me to be most efficacious for thoroughly clearing up the dangers connected with the coast is to offer rewards to the fishermen. Some years ago, when I was in China in command of a survey on the China station, the Chamber of Commerce of Hong Kong voted a sum, which they placed at my disposal for this purpose. Some of the money was used, and the rest was returned when the ship left the station. If a similar plan were adopted everywhere, I think there would be no difficulty about clearing up the question where these rocks are without using otter trawls, or this application of the kites of James' sounding machine. It seems to me also that a large sum of money ought to be voted by the Government for this purpose, in England. As far as I know, nothing is specially set aside for that purpose. I should say that a sum of £2,000 or £3,000 per annum would not be excessive if it enabled us to give such rewards to fishermen as would clear up all the dangers round the British coast. I should like to say that the machine mentioned by Lieutenant Helby, which he considers could be used for a breadth of 100 yards, and which is an application of James' sounding machine, is, in my opinion, quite useless. I do not believe the James' sentry can be used for that purpose at all on account of the nature of the kites and the strain on the lines on the quarter. I do not believe a rudder such as he describes attached to each kite would answer the purpose at all; and if it did, it would so deflect the angles of the kite (which was originally invented for towing astern) that it would be useless. With regard to the otter arrangement, it seems to me that you might just as well use an ordinary sentry astern. It does not spread over a very large distance, as far as I know, though the lecturer has not told us exactly what the distance is. I do not think it would do much more good than if you used the sentry right astern. The whole question is one of pounds, shillings, and pence. Taking it as a pretty rough rule, in a sea where there is any tide-way or strong current, a survey on a scale of 10 inches to the mile will cost ten times as much as that on one inch to the mile. I think you will probably agree with me that that is a fair estimate. If the Government is prepared to vote a sum of money for the surveying service which is ten times the amount they vote now, I have no doubt you can make every part of the world, in the course of a few hundred thousand years, perfectly safe; but during that period a great deal of time would be lost owing to the most important parts being only partially surveyed. It seems to me the system which the Hydrographer is using now is the right system, namely, to insist upon close soundings, and to survey those places only on large scales where ships are probably likely to anchor, and the approaches to anchorages. The whole thing is a matter of money. If Parliament will vote ten times the sum of money they do now, I have no doubt the Utopian desires which Lieutenant Helby has placed before us this afternoon will be realised. As Lieutenant Helby remarks in his paper, the pinnacle rocks are the great difficulty. In China, pinnacle rocks are usually found by two methods. In the first place, on a calm day—which is an extremely rare occurrence—the set of the tide shows a fan-shaped ripple over them, and you can detect them in that way; but more often than not they are detected

by a deeper sounding than the average. You may get a sounding of 15 fathoms, we will say, between two soundings of eight fathoms, and that indicates a scour round the hard surface of the rock. I do not think the systems which have been presented to us this afternoon will clear up the difficulty with pinnacle rocks, because I do not think that either of them is feasible.

Captain W. F. MAXWELL, R.N. :—I was unaware that this lecture was to be delivered until this morning, so I am totally unprepared to speak. Fortunately I think everything in connection with the subject has been said by the Hydrographer and Admiral Moore, except one thing, and that is with regard to the use of the otter trawl. I have had some little experience of the otter trawl, and I have seen it in use during my surveys of the North Sea and on the banks south of Scotland and south of Ireland. I think there might be developments of the otter trawl which would possibly give it an area, as Lieutenant Helby says, of 120 feet; no more certainly; that would be the very outside limit. I have never really thought about that question; it is an absolutely new idea to me. The difficulty is one that we are all familiar with in the ordinary dredging for rocks, and I do not see how it can be got over, namely, the difficulty of maintaining the so-called wire or bar or whatever you use at the depth at which you wish to dredge. I dredged last year for a rock at Valentia, and we exhausted every possible means. We sounded until we could not sound any more; but the opinion was so strong that there was a rock there that I undertook to dredge in the usual fashion, which is known to all surveyers here. The only result we got was that we found by a series of careful surveys a depth of 17 feet could not possibly exist there; but the dredging over that small area—an area I suppose not more than 100 feet square—took us three low waters of spring tides, so that you can imagine what the cost of a complete survey would be if we had to spend three spring tides dredging over an area of 100 square feet. The cost of sweeping, unless a new method is devised, would be enormous. On another occasion I dredged the Carlingford Gut, which was a thing that had to be tested to within a few inches, because the Harbour Commissioners on the one hand said the depth was there and the steamship company, on the other hand, said the depth was not there. The dredging of that particular place, which is not wider than a common street, in fact not as wide as the ordinary London street, took us four whole low waters of spring tides. That is another example of what the expense would be unless some new system were established. We dredged with a 30-foot iron bar, and supposing you multiply that by four—I do not believe the otter could possibly do more than 120 feet—you will see that the cost would be of making a survey, even of the entrance of a small harbour by dredging.

The CHAIRMAN :—Knowing what you do of the practical use of the otter trawl, do you think that you could stop and turn round a corner with it?

Captain MAXWELL :—No; you have to get in your otter again.

The CHAIRMAN :—You have to haul in each time?

Captain MAXWELL :—Yes.

Captain E. W. CREAK, C.B., R.N. :—I hope the Hydrographer and Admiral Moore will agree with me that the lecturer has missed one

point, namely, that in rounding corners closely a danger may exist which he has not noticed, and to which no soundings, however close, will give a clue. I refer to the possible disturbance of a ship's compass caused by highly-magnetised material in the bottom over which she may be passing. Supposing, for instance, a ship is steaming in a northerly direction past a Continental coast or island in the Northern Hemisphere; if she hugs the shore or rounds a point too closely it is possible that the north point of the compass will be drawn towards the shore, and she will be in danger, especially at night. There is a ready means by which the localities subject to these magnetic disturbances (magnetic shoals they have been called) can be found, and which has already been used to great advantage by the Hydrographer and Admiral Moore. I call attention to this subject because there is a tendency nowadays to cut corners, and in my opinion, in view of what I have just said, it is a very risky operation. There are several places in the world which, I think, should be particularly examined as regards local magnetic disturbance. I have heard that the Hydrographer has taken the question in hand, and I hope he will see it followed up in all parts of the world where a surveying-ship is at work. It is a very important question, which is hardly realised by many sailors.

Commander W. F. Caborne, C.B., R.N.R. :—The subject dealt with in the paper we have just listened to has never hitherto, I believe, been brought before the members of the Institution, and, accordingly, Lieutenant Helby is to be congratulated upon having taken a new departure. That great reliance is deservedly placed upon the Admiralty charts is certain, and all seamen owe a debt of gratitude to the British Hydrographic Department, which I may fearlessly characterise as the best in the world. Such being the case, and holding the opinion that it is usually wise to let well alone, I recently read in a great London newspaper, with much concern, that one of the projected naval reforms is the transference of the hydrographic section of the Admiralty to the Board of Trade. It is to be hoped that this is only an idle rumour, as the latter would not be able to conduct the surveying service so efficiently as the former has done in the past, not because the Board of Trade would not endeavour to carry on the work in a satisfactory manner, but rather because it possesses no adequate machinery for the purpose, and has had no experience in this particular direction. The lecturer remarks: "That merchant-ships, especially steamers, having an Admiralty chart of the coast on board, rarely trouble to use the lead so long as they are able to fix their position by the land." My official connection with the Wreck Court has shown me that many strandings are due to the neglect of the lead when the weather is too thick to fix the position of the vessel by sight or by any other means. According to my experience, the accuracy of our charts is most satisfactory. It is true that upon one occasion, when passing through Banka Straits, in August, 1883, I discovered a considerable difference between the soundings shown on the Admiralty chart and those given me by the leadsman. However, when I add that the particular day in question was the date of the great earthquake in the Straits of Sunda, when the whole world appeared to be splitting up and coming to an end, the discrepancy may be readily accounted for without in any way impugning the work of the surveyors. Among the unsuspected dangers discovered in much frequented waters by the simple process of ships striking upon them, may be mentioned the Avocet rock, formed of coral and with only fifteen feet of water over it, situated some eighteen miles north of Jebel Zukur, in the Red Sea, which obstruction caused the loss of the

steam-ships "Avocet" and "Teddington" in 1887, and was re-discovered, after much difficulty, by H.M.S. "Stork" in 1888. Is it not possible—and I throw this out more as a suggestion than a probability—that in connection with some of these rocks an alteration may have taken place in the formation of the bottom? Coming to the concluding paragraph of the paper, the lecturer speaks of underwriters probably making it a condition of insurance that vessels should navigate in certain defined "swept" tracts. At the first blush, it would seem that underwriters have a special interest in encouraging, and indeed compelling, the adoption of any means calculated to minimise the chances of maritime disasters; but there is another side to the argument. If we were to succeed in abolishing all maritime risks to-morrow, the occupation of underwriters would also be gone—a prospect which those gentlemen could not be expected to view with absolute equanimity. A certain number of casualties is necessary to their existence, and it must be remembered that the greater is the risk the larger is the premium, and *vice versâ*.

Lieutenant H. T. A. Bosanquet, R.N., in reply, said:—I am very sorry that Lieutenant Helby is not here to-day to defend his own paper; but I should like to make a few remarks on the criticisms which have been made. The Hydrographer said that provided the scale of the chart is sufficiently large it is highly probable that most of the dangers will be found. When the Hamoaze, Plymouth, was being sounded in 1894 on a scale of 14 inches to a mile, a single shoal sounding was obtained on the edge of the Rubble Bank, almost exactly on the leading mark. As there was a lop on at the time, the officer surveying considered it might be a false cast; he nevertheless ran a number of lines of soundings in the neighbourhood about 35 feet apart, without finding any further indication of shoal water. It was not until some time later, when the Rubble Bank was being deepened, that a dredger's cable got foul of a rock at the same spot, with only 28 feet of water on it. The top of this rock was only 2 feet square, and the diver who found it could only stand on it with care. It was in fact a typical pinnacle rock, and it was the purest chance that the lead had once alighted on it.

Rear-Admiral Moore:—He had an indication of it.

Lieutenant Bosanquet:—But he was not able to find it, and it was taken off the chart.

Rear-Admiral Moore:—I submit that that was an error of judgment on the part of the officer.

Lieutenant Bosanquet:—The otter sweep has been very much criticised. Lieutenant Helby only put that forward as a suggestion. His otter sweep has not been tried, but he suggests that experiments might be made with something on similar lines. There is a very great difference between the old type of deep-sea lead and Thompson's sounding machine, and if some of our inventors—Lord Kelvin, for instance—would turn their attention to the system of sweeping, some sweep might be devised which would be really practical. Captain Maxwell referred to the time taken when sweeping. That, of course, is a very grave objection; but if the steam-boats of our fleets in some of our largely used harbours were to carry out regular and systematic sweeping, a good deal might be done in that way. Lieutenant Helby has furnished me with the case of the Channel Fleet which

went quite recently to Loch Aber in Scotland, where Lord Charles Beresford's flag-ship very nearly ran on an uncharted rock, and it was only through the captain of a private yacht, who called on the Admiral and pointed it out after the fleet had anchored, that he knew of its existence. The steam-boats might have swept here with advantage. Commander Caborne has mentioned the alteration of the formation of the bottom; that may be, but it certainly does not bear upon the case of the coral reefs of *dead* coral. For instance, the "Duke of Buckingham" sank on the Pearn Reef, which is of dead coral and unalterable. There must be many such in steamer tracks which have not yet been found, and which only sweeping can find.

The CHAIRMAN (Rear-Admiral Sir W. J. Wharton, K.C.B., F.R.S.):—I am sure we are all deeply obliged to Lieutenant Helby for having brought this subject forward. We have had some most interesting remarks made by officers who have very great experience in the matter, and therefore what they have said is very valuable. The author has taken for his subject a question which, speaking broadly, is one of very great difficulty, namely, what is the best way to proceed with the survey of the depth under the water. In a place like this world of ours, which is so large, the progress of any complete marine survey must be slow. I was often asked when I was at the Admiralty when the hydrographic survey would be completed. I have always said: "Never; we have not done a millionth part of it yet." I do not know a harbour anywhere that is what I should call properly surveyed for modern requirements; that is to say, to allow a vessel to go within a few yards of the depth shown as safe for her, if she can be navigated so closely, with absolute certainty that she will not strike. That is the ideal. It is not so much our ideal as surveyors', because we know that vessels cannot be navigated to that degree of nicety; but it is the ideal of our brother seamen who, having fast steamers, like to cut the corners, as everybody else in this world does. When I was Hydrographer I used to feel a very great difficulty in settling what the scale of the different surveys should be, because, as Captain Field said, it all depends upon the scale of survey whether your chart can be considered as accurate or not, with regard to the chances or not of having a rock left out of it. I do not know anything more difficult to settle. Generally speaking, it is the very last place in the world that you would expect a ship to want to go that ships, especially His Majesty's ships, have to go. A case in point occurred the other day, which the lecturer referred to, in the grounding of the "Leviathan." She went into a perfectly open bay in the vicinity of Wei-Hai-Wei—quite a proper place for temporary anchorage. The survey, however, had been done under my orders, on a scale of one inch to the mile, in which it is absolutely impossible to make certain that a rock is not left undetected; but at the same time, if I had doubled the scale, or made it a 3-inch scale, the survey of that open coast, instead of taking three years, which it is taking, would have taken ten or eleven. One has to take all those points of view into consideration, and endeavour to arrive at an opinion as to how the requirements of navigation are best served. You must take a certain amount of risk, as you have to do in all things, and, as Captain Field says, I think some surveys as at present on small scales will probably continue. I have often considered whether it would be in any way possible to warn sailors by placing something upon each individual chart as to what the scale of original survey was, and the way in which the published sheet is compiled; but I always had to give that up. There

are so many charts made up of different surveys, and if you put it on one chart you would have to put it on all, so that it is a thing you cannot do. The only thing for navigators to do is to be careful, and not to cut corners too close, as they often do. But that is not so much the point as the question of making a correct survey, and not leaving anything undetected behind. As Captain Field says, I am sure that if anything in the way of a really efficient plan of rapid, effectual sweeping could be devised, he would be very glad to try it. It is possible that something may be done with a combination of the otter trawl and the James' sentry, but I see a great many difficulties connected with it. Lieutenant Helby refers in his paper, I notice, to expecting the ship to sweep. It is not so much the ship, however. You do not want a machine for a ship but for a boat to sweep with, because where there is a swell and a tide it is very seldom that a rock is left undetected, except such rocks as the Quetta, or the Avocet, which are a long way from the land, in broad channels with little sea. No device whatever could ever have detected the Avocet, which is out of sight of land, and certainly no one would have been justified in sweeping the whole of the Red Sea. You could not do it. The rocks that are undetected generally are rocks in close harbours, which, in the olden days, were not dangerous because big ships did not go in to them; which never show by swell, because there is no swell; and of which the fishermen as a rule know nothing at all. In all the rocks found in the last eight or nine years in the Scottish lochs, I do not think in any case the fishermen were aware of them. As a rule the fishermen do not know such rocks. I myself the year before last was up in one of the Scotch lochs that had been recently surveyed; I was on my holidays and was out fishing with my children. I said to the boatman: "Let us go now to the rock off the point there." He replied: "There is no rock there; I have been here all my life and my father before me, and my grandfather before him, and we have always fished there, and I know there is not a rock." I said: "I will take you to the rock, and show you it," and I did so. It was a very dangerous rock, and yet they knew nothing about it at all, so that you cannot trust fishermen in such a case as that. I would remind Admiral Moore, in reply to what he said as to fishermen being rewarded for pointing out dangerous rocks, that that is already provided for.

Rear-Admiral MOORE:—I know that the order has been given; but looking back upon my own career, I have not taken enough trouble to go round to all the fishermen at all the different places to make certain that they know about it.

The CHAIRMAN:—There was no discouraging giving money to fishermen; in fact I have been sat upon by the Treasury for paying fishermen. They wanted to know upon what authority I paid away the money, but I was able to rebutt the suggestion that I had wasted it.

Captain MAXWELL:—It was through paying some money to a fisherman that we found that rock off the coast of Newfoundland.

The CHAIRMAN:—That is rather an interesting case which Captain Maxwell has mentioned. It was stated that there was a rock 22½ miles off the coast of Newfoundland, south of Cape Race, right in the track of all steamers coming to the St. Lawrence. It had been searched for two or three times, and could not be found; but it was suggested that some of the fishermen knew something about it, and Captain Maxwell was directed

to go and see the fishermen at the nearest bays. At last he found a man who, with great unwillingness, confessed that he knew where the rock was, and he took Captain Maxwell out and showed it to him. It appeared that this rock, out in the middle of the sea, was a capital place for fish, and the man wanted to keep the secret to himself so that the other fishing boats could not fish there. When the other boats went away he used to go to this place. He knew it by certain bearing marks from the land, and he always made a good haul. He was discontented because we only gave him £20. That was a case in which a fisherman required a great deal of pressing in order to get any information from him. Then Commander Caborne suggested that the bottom might move sometimes. I think that when the rocks come up in that sort of way they give you plenty of notice; they come up amid fire and smoke, and everybody knows about it.

Commander CABORNE :—That is so as a rule, but I thought there might be some unknown movements sometimes.

The CHAIRMAN :—I do not think so. Such a thing has never been known in nature yet. I am sure you will all agree with me in according a very hearty vote of thanks to Lieutenant Helby for his paper.

Admiral Sir NATHANIEL BOWDEN-SMITH, K.C.B. : — It is now my pleasant duty to propose a vote of thanks to Sir William Wharton for taking the Chair this afternoon. Before I do so I want to utter a word of warning to Lieutenant Helby with regard to a certain shore danger, in return for the dangers that he has shown us to exist at sea. He warned sailors that they should not put too implicit confidence in charts, adding that some seamen expected the charts to be as perfect and as reliable as a Bradshaw's Guide. I would observe that Bradshaw's Guide is not always reliable, and if in making a long trip cross country he places too much confidence in it, he will some day find himself stranded in an out-of-the-way place, at some country junction without bed or supper. With regard to Admiral Moore's remark, that we should have to spend ten times as much as we do now on surveying if a more thorough survey were carried out, I can only say that with the income-tax at 1s. in the £, I am afraid we cannot hope that the world will ever be thoroughly surveyed if it is to be done mainly by British vessels. I am sure you will join with me in according a hearty vote of thanks to Sir William Wharton for occupying the Chair